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two basal principles of Heredity and Variation, this principle of Isolation constitutes the third pillar of a tripod on which is reared the whole superstructure of organic evolution." Natural Selection is regarded as merely a special case of isolation when the best fitted are separated from the less fit by the death of the latter. The following chapters are concerned with another special case of isolation, namely, Physiological Selection. Here are brought together in convenient form the chief facts and arguments in regard to this important subject. This is followed by a chapter giving a brief history of the opinions on isolation as a factor of organic evolution, and the general conclusions of the whole work are summed up in a final chapter.

The book is largely controversial in tone, and the arguments are presented, of course, from the standpoint of the well-known views of the author. Still, the other side is at least given a hearing, and we have in the three volumes as a whole what we have not had before, — a complete work on organic evolution reflecting the thought of recent times.

ZOOLOGY.

A Viviparous Holothurian. — The life histories of the few holothurians that protect their young during the early stages of their development afford some most peculiar and interesting instances of adaptation, as regards both structure and habits.

The transference of the eggs in *Cucumaria planici* to an atrium in front of the mouth and encircled by the tentacles, there to be fertilized by spermatozoa thrown out by a neighboring male into the surrounding water, which is swept into the atrium by the movements of the tentacles of the female, is well known from Selenka's account of the process.

We are also acquainted with the conditions in *Cucumaria glacialis* Ljungman in which Mortensen¹ describes a pair of broad pouches, invaginations of the body wall in the ventral interradii, immediately behind the circle of tentacles. The large yolk-filled eggs (diam. 1 mm.) after being laid are presumably taken up by the female from the sea bottom into the pouches. Similar brood sacs are found in another Arctic species, *Cucumaria minuta* Fabr., and in *C. laevigata* Verr. of the Antarctic seas.

¹ Th. Mortensen, Zur Anatomie und Entwicklung der *Cucumaria glacialis* (Ljungman). *Zeit. f. wiss. Zool.*, Bd. lvii, pp. 704-732, Taf. 31, 32. 1893.

Another curious adaptation has been described by Ludwig¹ in *Chirodota contorta* Ludw., also from the Antarctic. In this animal the reproductive tubules themselves serve as receptacles for the young until they have attained a length of 3 mm. or more, when birth takes place through the outer opening of the genital duct.

Furthermore, the attachment of the eggs of *Cucumaria crocea* Less. and of *Psolus ephippifer* W. Thoms. to the dorsal surface of the mother, where the young are reared, is a fact that is familiar to all naturalists.

In still other holothurians the eggs have been known to find their way in some hitherto unexplained manner into the body cavity, where they develop. One of these forms is *Synapta vivipara*, originally described by Oerstedt from specimens taken in the West Indies. It is probably identical with Theél's *Synapta picta*, which the Challenger Expedition took at the Bermudas.

Synapta vivipara has recently been thoroughly studied by Dr. Hubert Lyman Clark² in the Johns Hopkins Marine Laboratory at Port Henderson, Jamaica. It is to be found in the quiet pools in the rear of Port Royal, clinging to the red seaweed *Acanthophora*, which is attached to the roots of the mangroves.

The eggs probably burst through the thin walls of the bisexual reproductive tubules into the body cavity; they were never observed in the genital duct, nor were passages from it into the body cavity discovered. The duct runs forward into the body wall, but ends blindly in the connective tissue beneath the external epithelium.

Spermatozoa were found abundantly both in the duct and in the connective tissue about its blind end; hence it is believed that they pass outward through the epithelium of the end of the duct, the connective tissue layer, and the thin external epithelium of the body wall. Thence they are believed to make their way to another individual, and by passing inward through the anus and certain apertures in the walls of the rectum into the body cavity they meet the ova.

Apparently ripe spermatozoa and ova occur simultaneously in the same reproductive tubule, but there is nothing to indicate that the spermatozoa ever pass from its lumen through its wall into the body cavity. Indeed, no direct evidence has been obtained to show either that self-fertilization does or that it does not take place in *Synapta vivipara*.

¹ H. Ludwig, Ein neuer Fall von Brutpflege bei Holothuriern. *Zool. Anz.*, Jahrg. xx, Nr. 534, pp. 217-219. 1897.

² H. L. Clark, *Synapta vivipara*: A Contribution to the Morphology of Echinoderms. *Memoirs Bost. Soc. Nat. Hist.*, vol. v, No. 3. 1898.

H. L. Clark, The Viviparous *Synapta* of the West Indies. *Zool. Anz.*, Jahrg. xix, Nr. 512, pp. 398-400. 1896.

Without considering in detail the development of the larvæ, we will discuss certain features of the process which are of such especial interest as to merit the attention of the general reader.

The ciliated gastrula which swims freely in the body cavity of the mother presently becomes transformed into an oval embryo without ciliated bands; a mouth at this stage is found upon the ventral surface of the body, but there is no anus; the blastopore has closed. A pair of cœlomic pouches are present, as well as a hydrocoel, which has upon its anterior face five large interrarial outgrowths (the canals of the primary tentacles) and five smaller *radial* outgrowths, each of the latter being situated at the right of one of the former. An *adradial* water canal opens upon the surface of the body by a dorsal pore.

Thereupon follows a *pentactula* stage in which the hydrocoel, its extremities having united near the mid-ventral line, forms a ring; a Polian vesicle is present in the left-dorsal interradius; the central nervous system has been established, the nerve ring having been derived from a thickening of the ectoderm which surrounds the mouth, the radial nerves, as well as nerves to the tentacles, having arisen as outgrowths from the circular nerve band; five pairs of otocysts lie external to the radial nerves at the point where they bend to run backward; the mouth, situated in the center of a circle of tentacles, opens into an œsophagus lined with endoderm; the stomach is large; the intestine makes a single loop; an anus is now present at the posterior extremity of the body; a mesentery, formed by the fusion of the right and left cœlomic pouches, attaches the alimentary tube throughout its whole extent to the body wall.

The pentactula then becomes transformed directly into the larva with ten tentacles which, when it has attained a length of about 5 mm., is set free from the parent. In some cases, however, young individuals 15 mm. or 20 mm. in length have been observed still within the body cavity of the mother. Birth takes place by the rupture of the body wall near the anus, or, more frequently, by a perforation through the wall of the rectum, in which case the young finally escape through the anal opening.

The most striking feature of the abbreviated course of development of *S. vivipara* is the complete lack of radial water canals of the body wall, even in the embryo. It seems to be definitely determined¹ that in *S. digitata* these canals are formed in the early stages of

¹ R. Semon, Die Entwicklung der *Synapta digitata* und die Stammesgeschichte der Echinodermen. *Jena. Zeit.*, Bd. xxii, pp. 175-309, Taf. 6-12. 1888.

development, and it is equally certain that in the adult of this same species, as well as in many or all other Synaptidæ, they are entirely lacking.¹ In *S. vivipara* the five primary interrarial outgrowths of the hydrocoel grow forward and constitute the canals of the five primary tentacles; the five secondary radial outgrowths extend forward, each to a point immediately in front of which a radial nerve passes outward in its course to the body wall. From three of the radial outgrowths of the hydrocoel branches soon arise, which grow forward on either side of a radial nerve and form the basis of the accessory tentacles; from the fourth or left-dorsal radial outgrowth a single branch arises, ventral to the radial nerve, forming an accessory tentacle of the left-dorsal interradius; whereas the fifth or mid-ventral outgrowth is never more than a slight protuberance, from which no accessory tentacles are normally developed, and which usually soon atrophies and disappears. None of the radial outgrowths of the hydrocoel is prolonged to form a radial canal in the body wall.

From the fact that no radial canals are ever developed in *S. vivipara* it is evident that we have in this form a more degenerate condition of the water vascular system even than in *S. digitata*. The fact that the stone canal in the adult *S. vivipara* has an opening directly upon the surface of the body, with a madreporite near the body wall having openings into the cœlom, would seem to indicate, on the other hand, that in this one particular the water vascular system has retained its primitive structure.

When, furthermore, we compare the water vascular system of the larva of *S. vivipara* at the stage with ten tentacles with that in *Cucumaria* at a similar stage, as described by Ludwig,² we find strikingly similar conditions. If the Synaptidæ have been derived, as Ludwig has suggested, from an ancestor the tentacles of which arose as branches from five radial outgrowths of the hydrocoel, and if we should, furthermore, suppose that subsequently by the gradual shortening of those outgrowths the five primary tentacles came eventually to arise directly from the hydrocoel ring, losing their immediate connection with the radial outgrowths, then we would have a complete homology between the conditions which Dr. Clark has found in *S. vivipara* and those in *Cucumaria* as described by

¹ H. Ludwig und P. Barthels, Zur Anatomie der Synaptiden. *Zool. Anz.*, Jahrg. xiv, pp. 117-119. 1891.

² H. Ludwig, Zur Entwicklungsgeschichte der Holothuriën. *Sitzungsber. k. preuss. Akad. Wiss.*, Nr. 10, pp. 179-192; Nr. 32, pp. 603-612. 1891.

Ludwig. Unless this assumption is made, however, the evident correspondence between the secondary tentacles of the two forms which Dr. Clark has pointed out would mean nothing, because the primary tentacles would not be homologous.

This entire assumption is plausible for these reasons: (1) there is an evident degeneration of the water vascular system of the Synaptidæ which would be expected to affect first the primary tentacles; (2) the primary tentacles can more easily be supposed to have originally sprung from radial canals than *vice versa*, since the secondary tentacles, in fact, are known to arise from radial canals, whereas there is little evidence in favor of the view of Semon that the tentacles in the primitive holothurian arose directly from the circular water canal.

An abundance of anatomical and histological evidence could be given to show that the Synaptidæ are more closely related to the Molpadiidæ (*e.g.*, Caudina) and their allies the Cucumariidæ than to any other groups of holothurians. Hence we may, as suggested by Ludwig, regard these three families as forming one of the two great branches of the family tree of the holothurians.

While the Synaptidæ retain some primitive characteristics, as, for example, hermaphroditism, they are in many respects highly specialized forms, particularly as regards sense organs. Otocysts, containing a single vesiculated cell, and sensory papillæ upon the surface of the body and the abaxial surface of the tentacles are described in *S. vivipara*. The ganglia found by Cuénot¹ at the base of these papillæ in *S. inhaerens* O. F. Müller have been observed also in *S. vivipara*. The structure of similar ganglia in *S. girardii* Pourtalès and *S. roseola* Verr. of our own coast has lately been investigated with methylene blue by the present writer.

When the larva has still only ten tentacles a pair of "eyes" appear in the connective tissue at the base of each tentacle, and later, when the last two accessory tentacles appear, one in each lateral dorsal interradius, another pair of eyes is formed at the base of each of them. A knob-shaped protuberance grows out from the side of each tentacular nerve, where it arises from the nerve ring, into the connective tissue, and becomes covered with a layer of mesenchyme cells. This mesenchymatous covering in the adult consists of a "rather horny" layer of light brown color, containing scattered nuclei; it is continuous with a thin mesoderm layer which is said to surround all the

¹ L. Cuénot, Études morphologiques sur les Echinodermes. *Archives de Biol.*, tome xi, pp. 313-680, Pl. XXIV-XXXI. 1891.

nerves; this covering becomes transformed into a thick, pigmented, lens-like structure. The "eye" proper consists of vacuolated cells of a prismatic shape; each is swollen at the free end and tapers at the other extremity, at which it is continuous with a nerve fiber.

It is remarkable that in *S. vivipara* no true sensory buds, the cup-shaped structures that are found in many Synaptidæ attached to the axial surface of the base of the tentacles, were discovered.

Nerves which supply the œsophagus and mouth region in *S. vivipara* are described. Similar nerves in *Caudina arenata*, ten in all, were investigated by the present writer.¹ These nerves have been observed in several other holothurians not noted by Dr. Clark, and in view of their widespread occurrence it is not improbable that they may yet be found in most, if not in all, holothurians.

In our brief consideration of this interesting holothurian we have noted the degeneration of the genital duct, the thinness of the walls of the reproductive tubules, and the apertures through the wall of the rectum, — all adaptations parallel with a most peculiar manner of protecting the young; we have considered the marked degeneration of the water vascular system, no radial canals being found even in the larva, and the significant fact that the tentacles in part spring from radial outgrowths of the hydrocoel, as in *Cucumaria* and *Caudina*; and, finally, allusion has been made to some features of certain sense organs which are found not only in *Synapta vivipara*, but also in other Synaptidæ.

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Shufeldt's Chapters on Natural History.² — The first thing which strikes one in opening this volume is the beauty of many of the illustrations, most of them half-tone reproductions of photographs direct from nature. Dr. Shufeldt has long advocated this method, and the results here presented fully justify his contention. There is a life to these illustrations which is lacking from even the best of products of pencil and brush; the artist represents the animal as he thinks it ought to look; the camera represents the animal itself. To us the best of the illustrations are that of the common swift (*Sceleporus*), those of the green snake and king snake (*Cyclophis vernalis*

¹ J. H. Gerould, The Anatomy and Histology of *Caudina arenata* (Gould). *Proc. Bost. Soc. Nat. Hist.*, vol. xxvii, pp. 7-74, 8 pl. 1896. Also *Bull. Mus. Comp. Zool.*, vol. xxix, pp. 121-190, 8 pl.

² *Chapters on the Natural History of the United States*. By R. W. Shufeldt, M.D. Studer Brothers, New York, 1897. 8°, pp. 472 [+ 8].